

Introduction: Communicating over long free-space distances is extremely difficult due to the inverse-squared propagation losses associated with link distance. That makes communications particularly difficult from outer planet destinations. For example, to send one bit of information back from Pluto is 20 billion times more difficult than sending that same bit from geosynchronous Earth orbit to the ground. Furthermore, while the size of the reception systems on the Earth can be substantial, the size, mass and power consumption of the deep space communications subsystem must be kept to an absolute minimum to keep the launch costs down. At the same time, the kinds of instruments being considered for detailed target body analysis include multi-spectral imagers and synthetic aperture radars. These sensors are capable of generating enormous quantities of data. Most past and current missions rely on radio frequency communications at the X-band (8 GHz) frequency. Many future missions will require the greater communications capabilities afforded by higher frequencies. Two technologies being developed for such applications are Ka-band (32 GHz) and optical communications (3×10^{14} Hz).

Ka-band Communications: Near-term mission enhancements will be available by using Ka-band communications. Factors of 4 increase in link capacity can be achieved with current technologies and factors of 10 are on the horizon. Numerous flight demonstrations have been conducted with Ka-band frequencies including modest demonstrations from SURFSAT, Mars Observer, and Mars Global Surveyor, and a complete Ka-band demonstration was conducted from the DS1 spacecraft. Additionally, Ka-band is being used on the Cassini mission for gravitational radio science.

Several technologies are being developed to enhance the capabilities of future Ka-band systems. These include large inflatable antennas (Fig 1), higher-power Ka-band power amplifiers, and phased-array feeds.

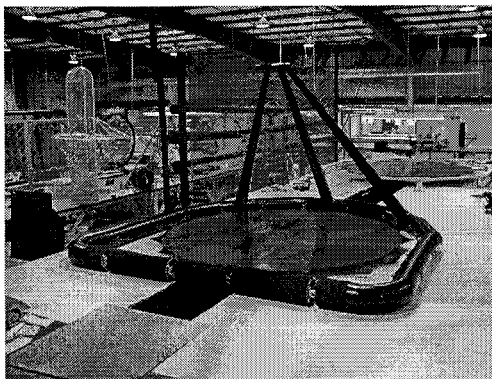


Fig 1. 3-m Diameter Inflatable Ka-Band Antenna

Additionally, work is underway to develop the ground systems technologies required to support Ka-band reception. These include multi-frequency dichroic plates, low-noise Ka-band maser and HEMT amplifiers, and compensation systems to allow the DSN's antennas to be efficiently used at Ka-band.

Optical Communications: Technology development has also been underway for optical communications. Although currently less mature than Ka-band, it offers advantages of 10-100 times increase in link capacity in the near term and far more in the longer term [1]. A flight terminal engineering model called the Optical Communications Demonstrator (OCD) has been developed [2]. The OCD has recently been used in field tests across a 46 km long mountain top-to-mountain top demonstration. An Optical Communications Telescope Laboratory (OCTL) is also currently being installed at JPL's Table Mountain Facility. This will be used to validate optical technologies and systems designs, and to support a series of near-term flight demonstrations. Additionally, JPL has developed and deployed a set of three Atmospheric Visibility Monitoring observatories for gathering space-ground atmospheric attenuation statistics [3].

Several precursor system-level demos have also been conducted. In December 1992, pulsed optical beams were transmitter up to, and detected by, the Galileo spacecraft after it passed the Earth for gravity assist. This was followed in 1995/96 by a series of two-way optical communications tests with the ETS VI satellite.

Opportunities for Light Science. Currently, RF communications signals are used for many functions including radio scientific investigations. By utilizing optical (light) beams, analogous kind of "light science" investigations will be enabled.

References:

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